Characterizing Cold Nuclear Matter Effects

through dielectrons in d+Au collisions at $\sqrt{s_{NN}} = 200GeV$ at PHENIX

Outline

- *Motivation – PHENIX dielectron review*
- *new d+Au result*
- *comparisons to*
  - *pp*
  - *heavy ion*
- *Summary*

Jason Kamin, Stony Brook University
PHENIX Collaboration
Quark Matter 2011
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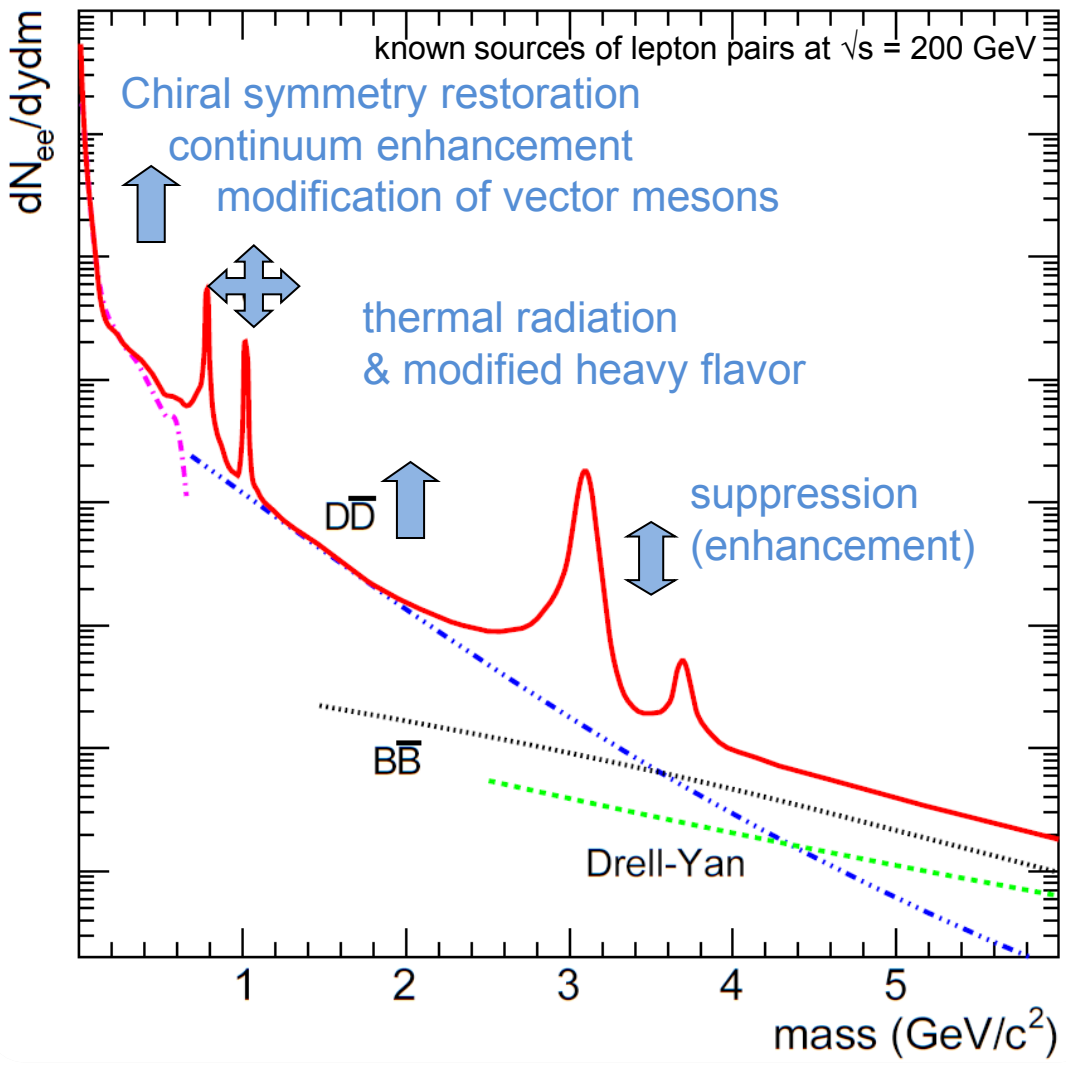
Lepton Pair Continuum

diverse physics

Modifications due to QCD phase transition



Sources "long" after collision:

- π^0, η, ω Dalitz decays
- (ρ), ω, ϕ, J/ψ, ψ' decays

Early in collision:

- Heavy flavor production
- Drell Yan, direct radiation

Baseline from p+p and d+Au

Thermal (blackbody radiation):

- in dileptons and photons
- temperature evolution

Medium modifications of mesons:

- $\pi\pi \rightarrow \rho \rightarrow \ell^+\ell^-$
- chiral symmetry restoration

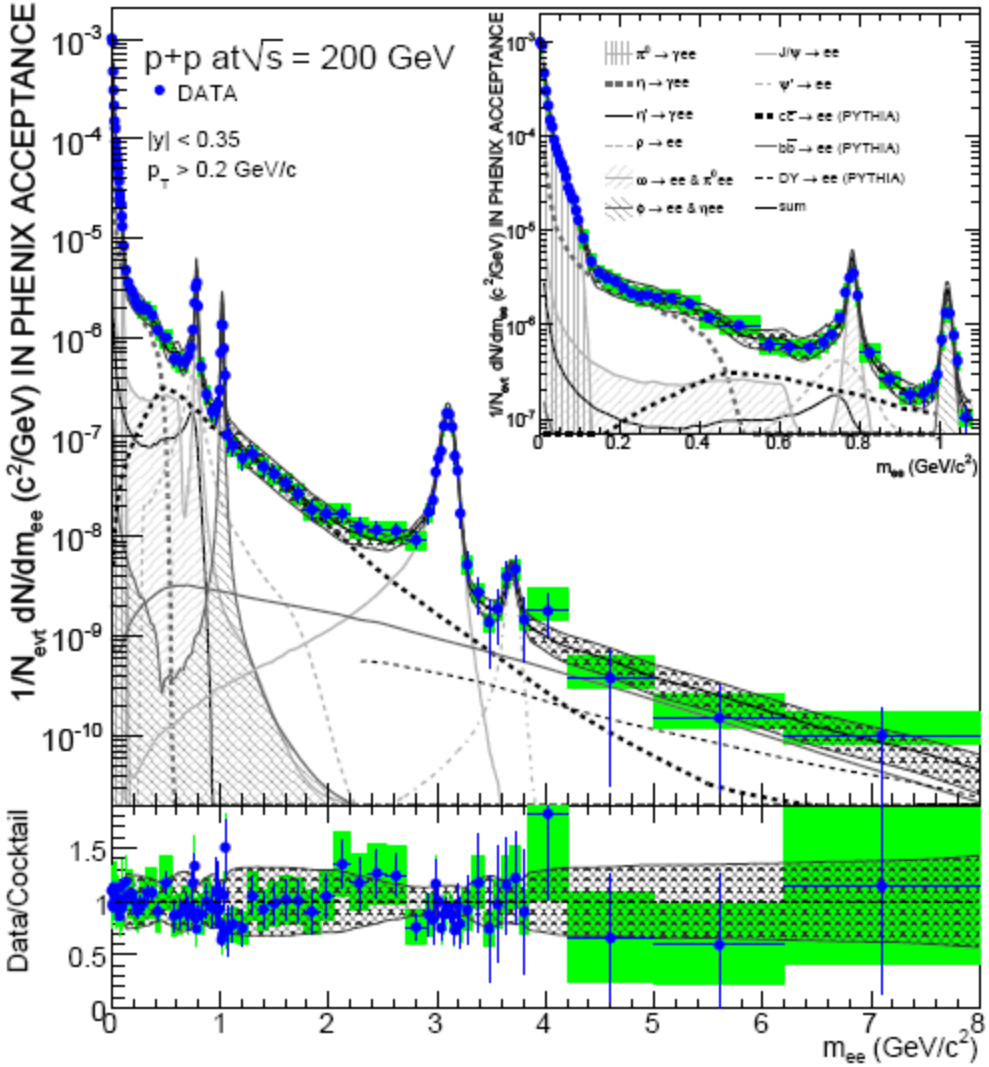
Medium effects on hard probes

- Heavy flavor energy loss

Large discovery potential at RHIC

p+p Dielectrons

fundamental basline for heavy ion



Phys. Lett. B 670, 313 (2009)

Low Mass Region:

- Excellent agreement with hadronic decay cocktail.

Intermediate Mass Region:

- Open Charm Continuum
- integrating the yield:

$\sigma_{c\bar{c}} = 544 \pm 39(\text{stat}) \pm 142(\text{syst}) \pm 200\ (\text{model})\ \mu\text{b}$

- agrees with single electron x-sec:

$\sigma_{c\bar{c}} = 567 \pm 57(\text{stat}) \pm 193\ (\text{syst})\ \mu\text{b}$

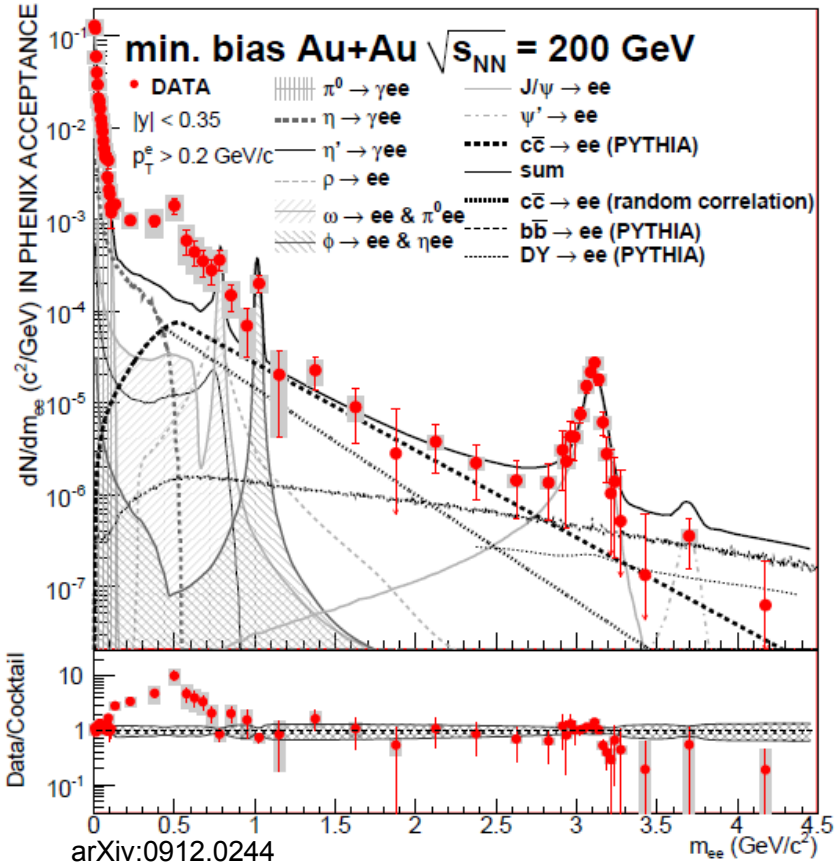
High Mass Region:

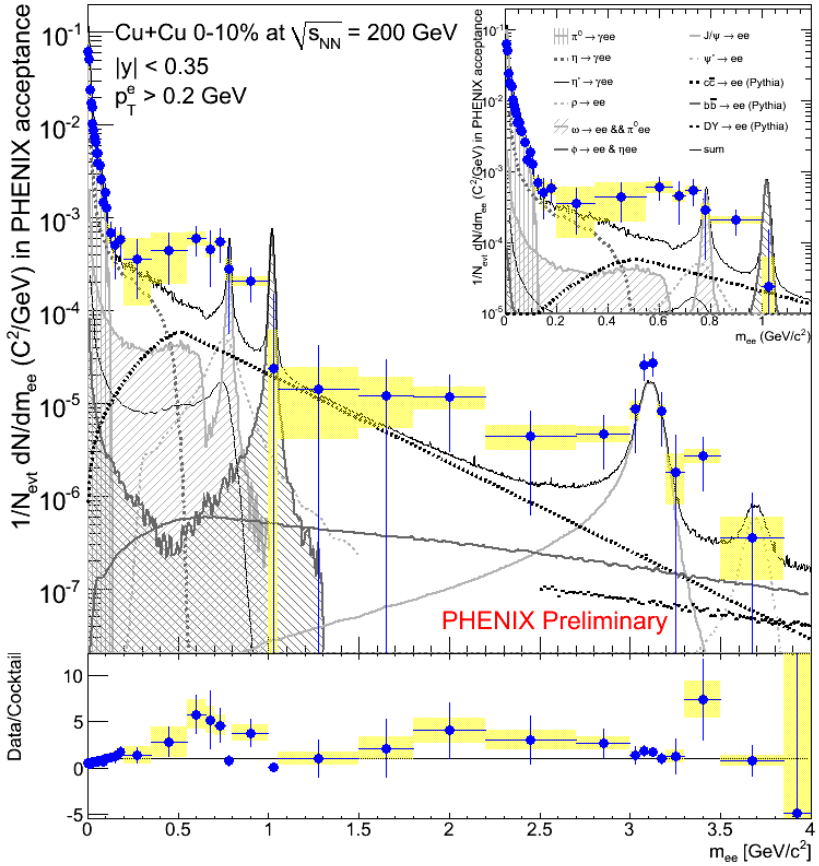
- Dominated by bottom

$\sigma_{b\bar{b}} = 3.9 \pm 2.4(\text{stat})\ ^{+3}_{-2}(\text{syst})\ \mu\text{b}$

Heavy Ion Dielectrons

Au+Au and Cu+Cu





- MinBias Au+Au compared to cocktail.
- striking enhancement below the ω mass (LMR)
- matches cocktail in IMR – surprise?

- Central Cu+Cu compared to cocktail.
- some enhancement seen in LMR
- hints of enhancement in IMR?

Continuum modifications need a better baseline

d+Au Dielectrons

motivation

Why look at dielectrons in d+Au?

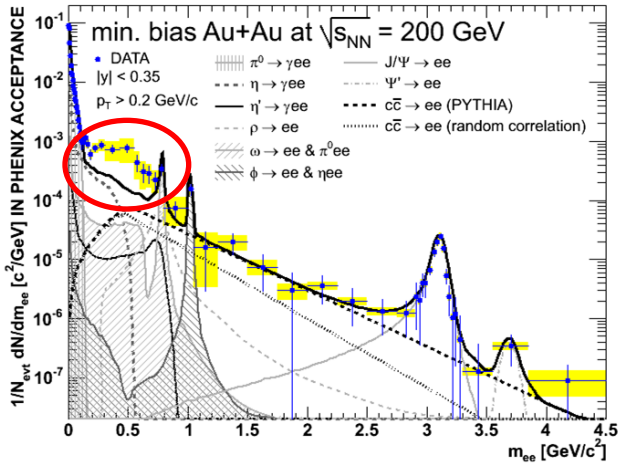
- Verify that the enhancement is due to the hot dense matter in AuAu.
- Can cold nuclear matter effects be seen in dielectron spectra?

What effects are at play in d+Au?

- Anti-shadowing at mid rapidity

- Contrast open and closed charm (and beauty).
  - eg. no absorption for open charm

- Other cold nuclear matter effects.
  - initial state energy loss
  - Cronin Effect?



Which effects might be relevant to the dielectron spectrum??

Estimate of Expected Sources

creating the "cocktail"

Hadron Decays:

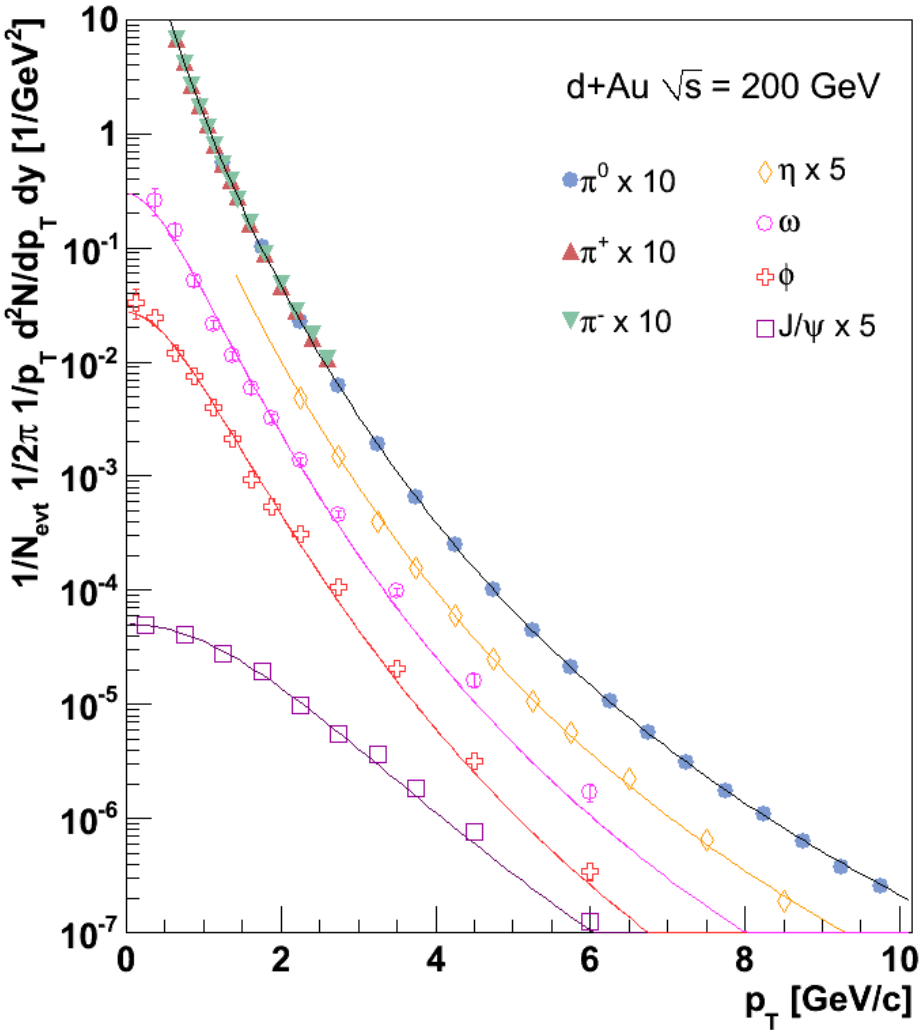
- Fit $\pi^{\pm}$ and π^0 data for collision system

$$E\frac{d^3\sigma}{d^3p} = \frac{A}{\left(\exp(-ap_T - bp_T^2) + p_T/p_0\right)^n}$$

- For other mesons η, ω, ρ, ϕ, J/ψ etc. replace

$$p_T \rightarrow \sqrt{p_T^2 - m_{\pi^0}^2 + m_{hadron}^2}$$

and fit normalization to existing data where available.



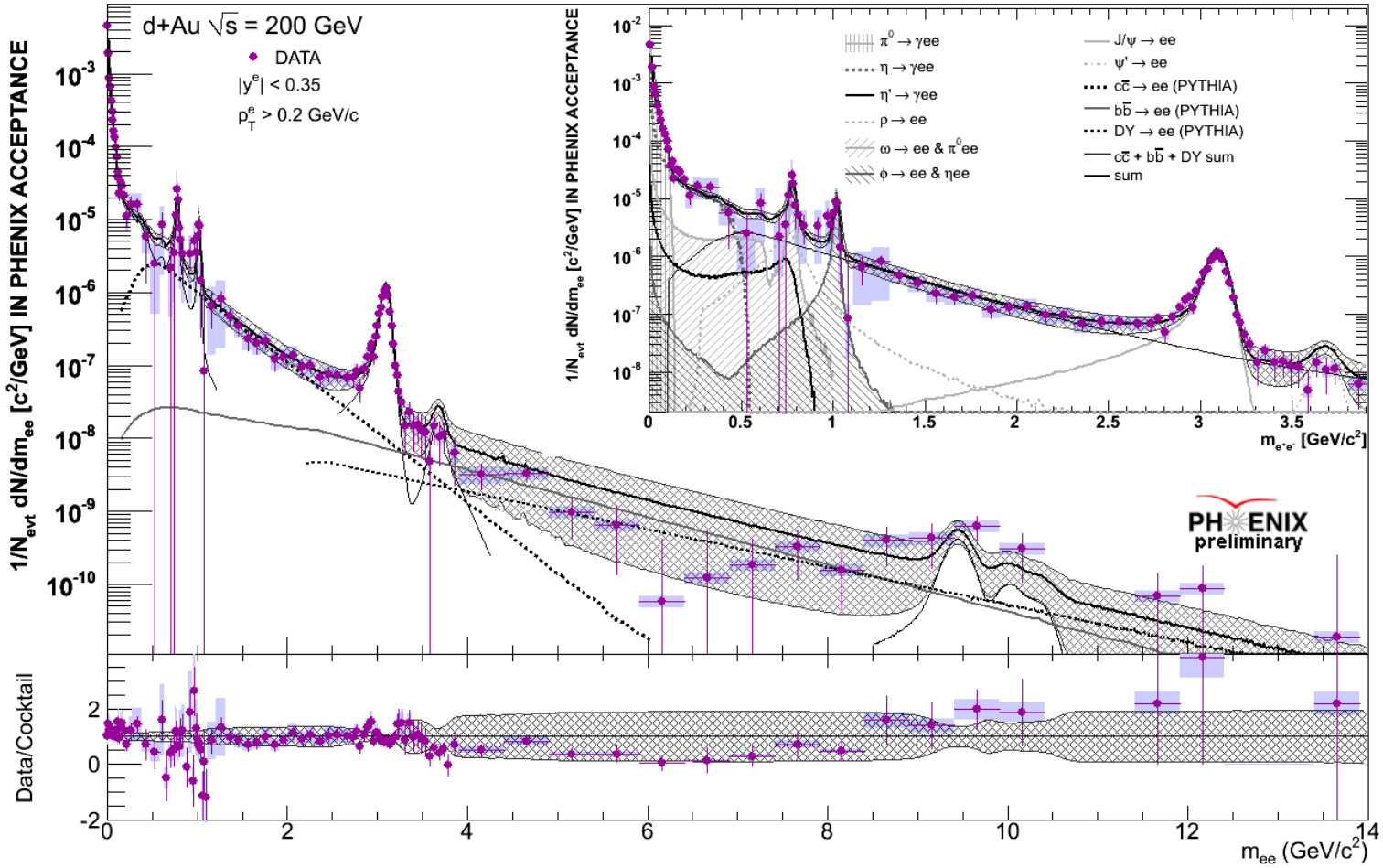
Heavy flavor production:

- Ncoll x 567 ±57 ±193 mb from pp single electron measurement.
- R_{dAu} of J/ψ included in cocktail.

Predict contribution from known pair sources

d+Au Dielectrons

preliminary results



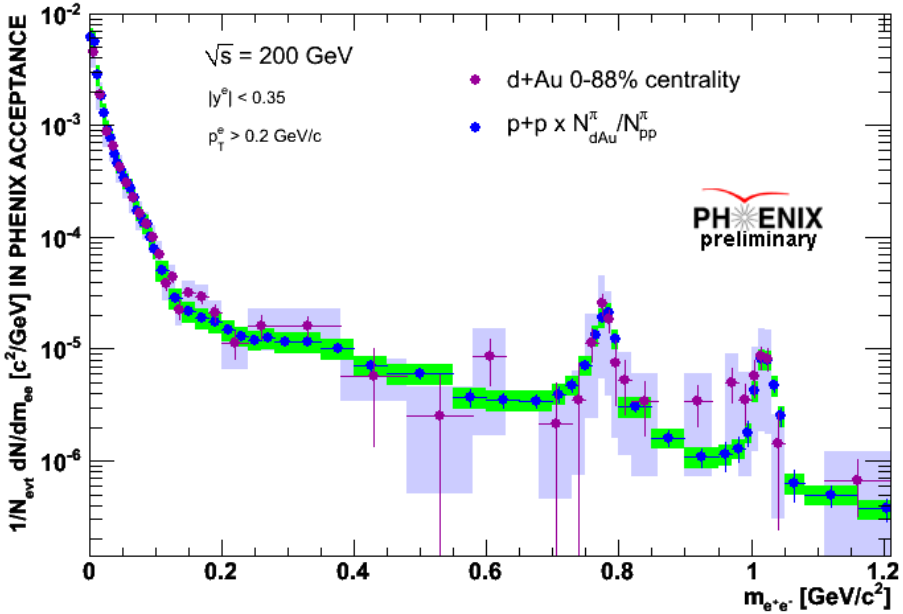
- no deviation from cocktail.
  - *Heavy ion effects are not seen in control system.*
- large mass range – out to 14 GeV.

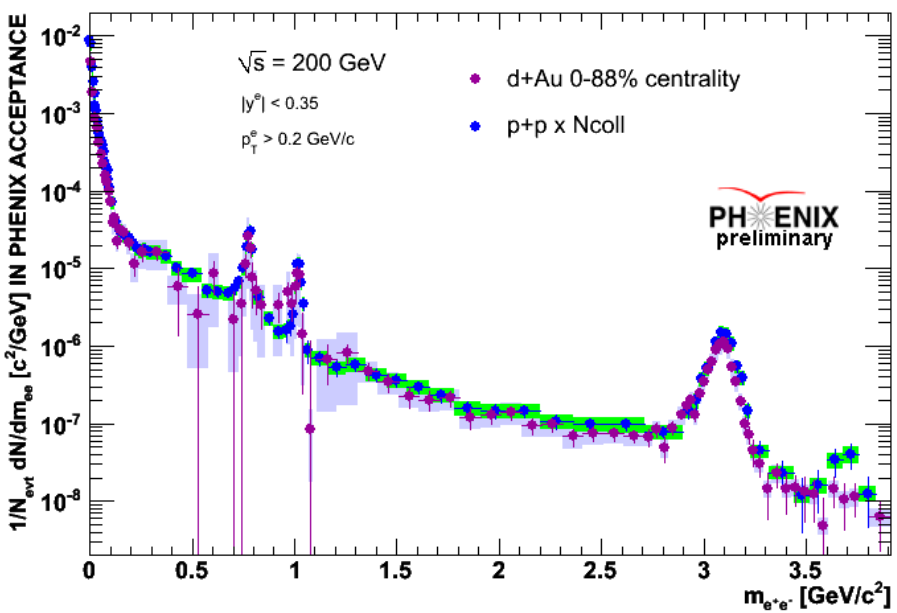
Compare to cocktail

- includes hadrons, heavy flavor, Drell Yan.
- large cocktail uncertainty due to bottom and DY.
- open heavy flavor - pp PYTHIA calc, Ncoll scaled.

Comparison

d+Au to scaled p+p





Low mass region

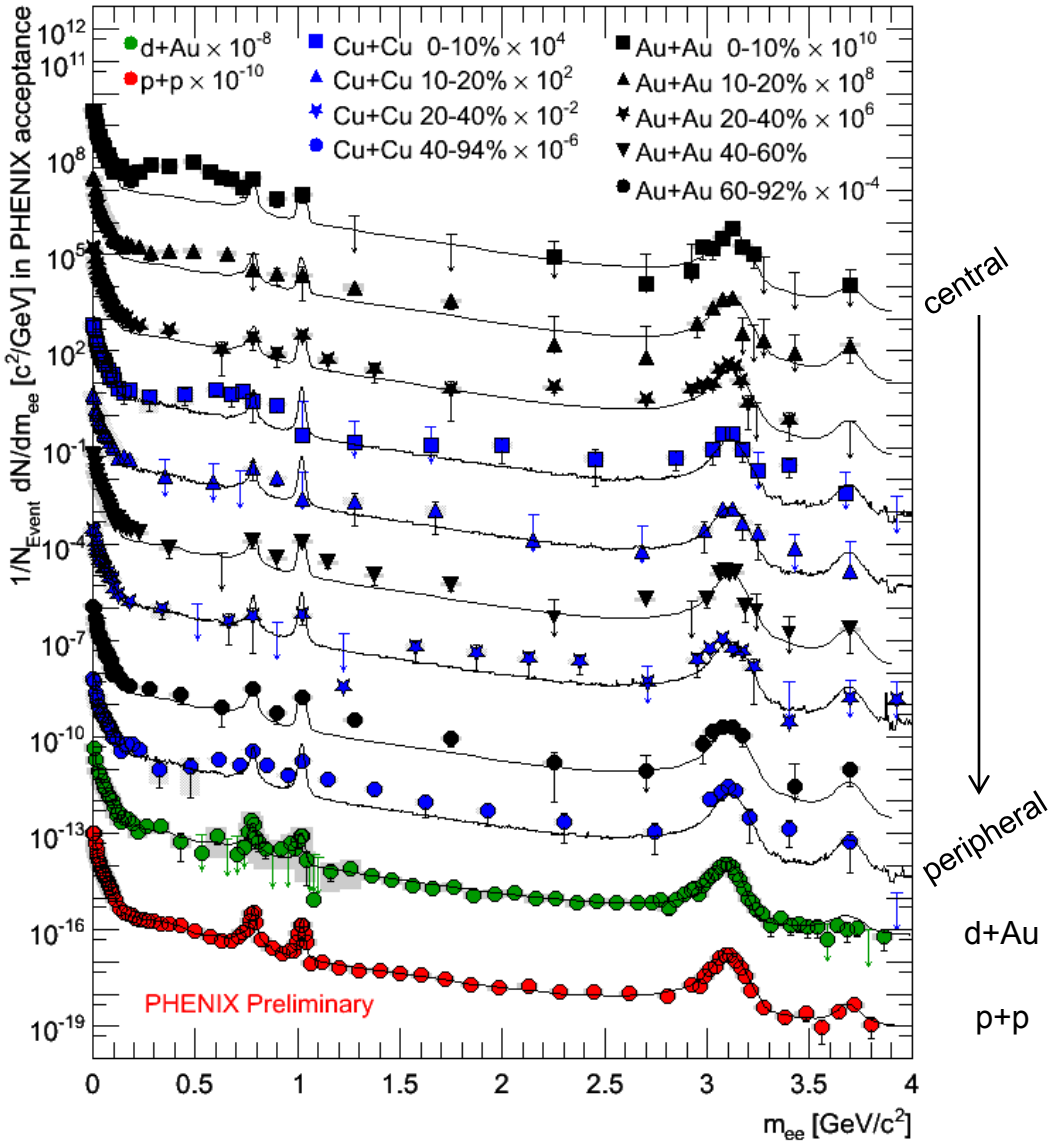
- no excess in LMR!
- d+Au consistent with scaled p+p
- d+Au consistent with hadronic cocktail
- large systematic uncertainty due to low S/B at low p_T.

Intermediate mass region

- no excess in IMR.
- d+Au consistent with scaled p+p
- d+Au consistent with hadronic cocktail
- J/ψ suppression of ~0.75 observed (see poster by D. McGlinchey, session 2; talk by A. Sen, Heavy Flavors - Tues)

Centrality Dependance

regions of enhancement



All PHENIX dielectron data

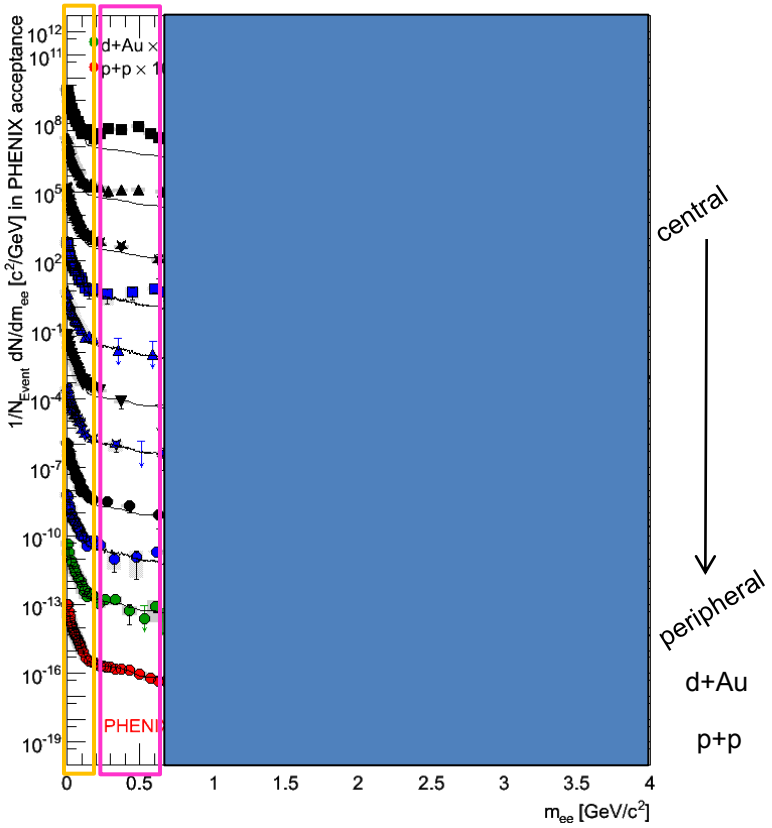
- Heavy ions, pp and dAu
  - AuAu by centrality
  - *CuCu also broken into centrality!*
- ordered vertically by N_{coll}
  - dAu and pp at bottom.
- black lines are respective cocktails.

Centrality Dependence

- LMR excess in more central
- *slight* IMR excess in peripheral heavy ion
- dAu and pp consistent with cocktail

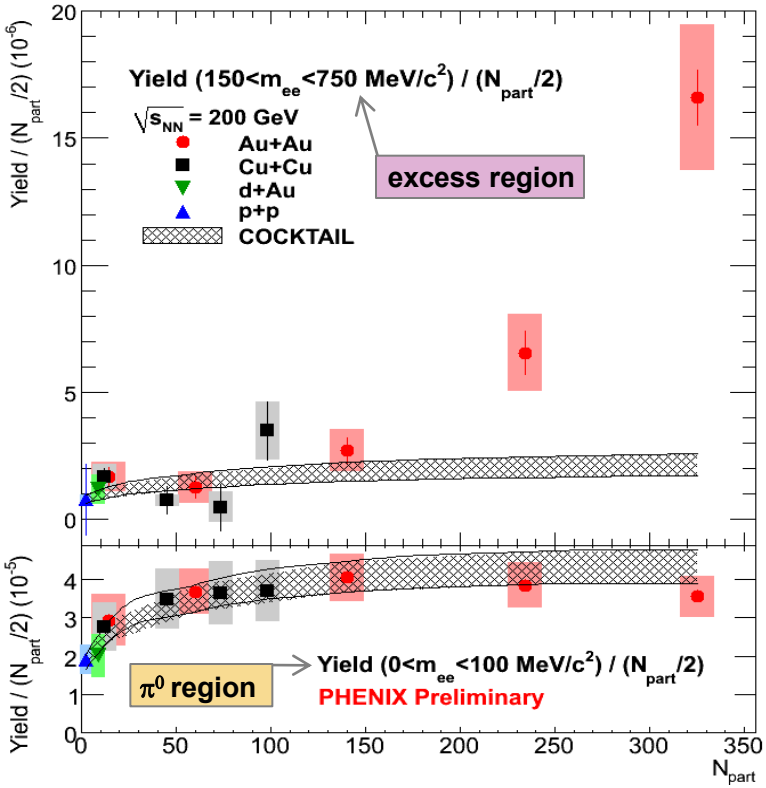
LMR Enhancement

Centrality Dependance



- Enhancement in low mass region is a strong function of centrality.
- Seen in both HI systems (AuAu & CuCu)
- excess not observed in pp or dAu

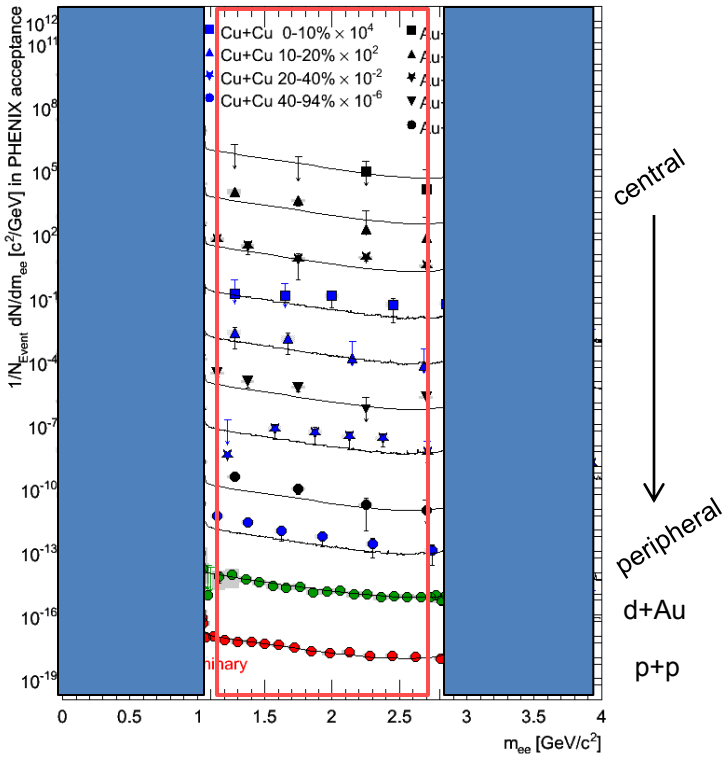
- Yield/(N_{part}/2) in 2 different mass windows
- π^0 region scales apprx with N_{part}
- Excess region:
  expect contribution from hot matter
  - in-medium production from $\pi\pi$ or qq annihilation
  - yield should scale faster than N_{part} (and it does!)

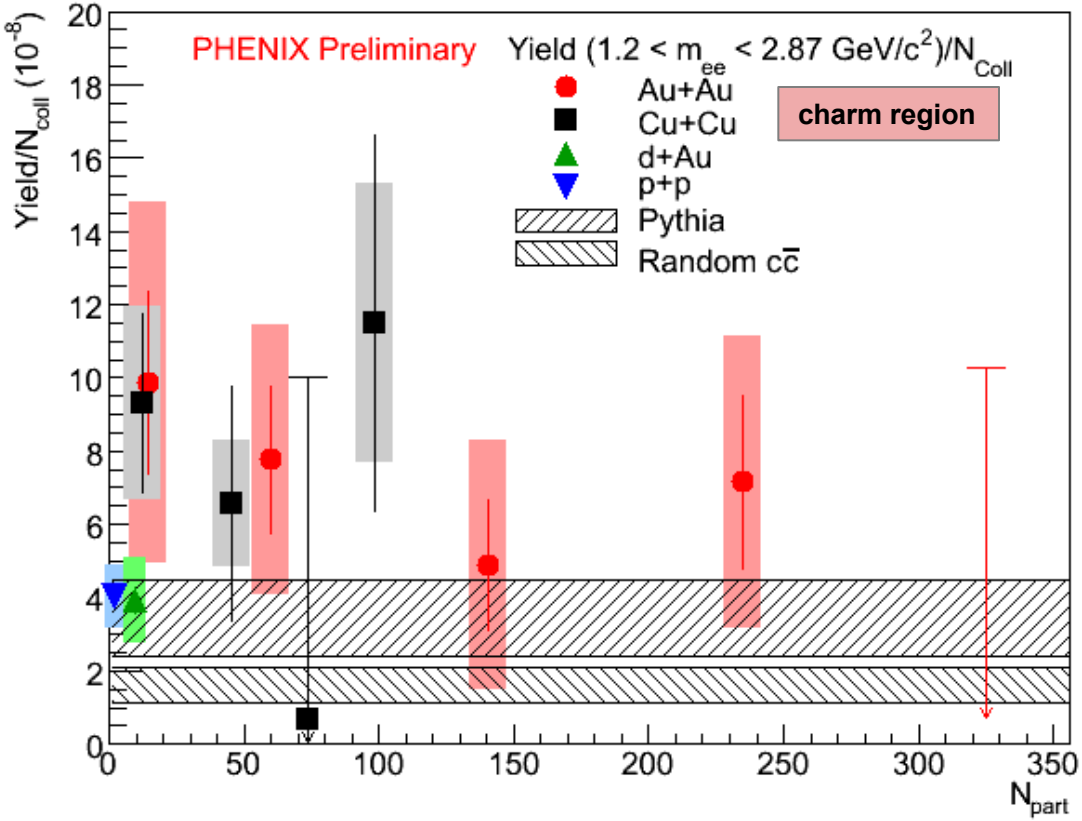


Excess mostly in central AuAu yield increase faster than N_{part}

Charm Region vs Centrality

1.2 GeV < m < 2.8 GeV



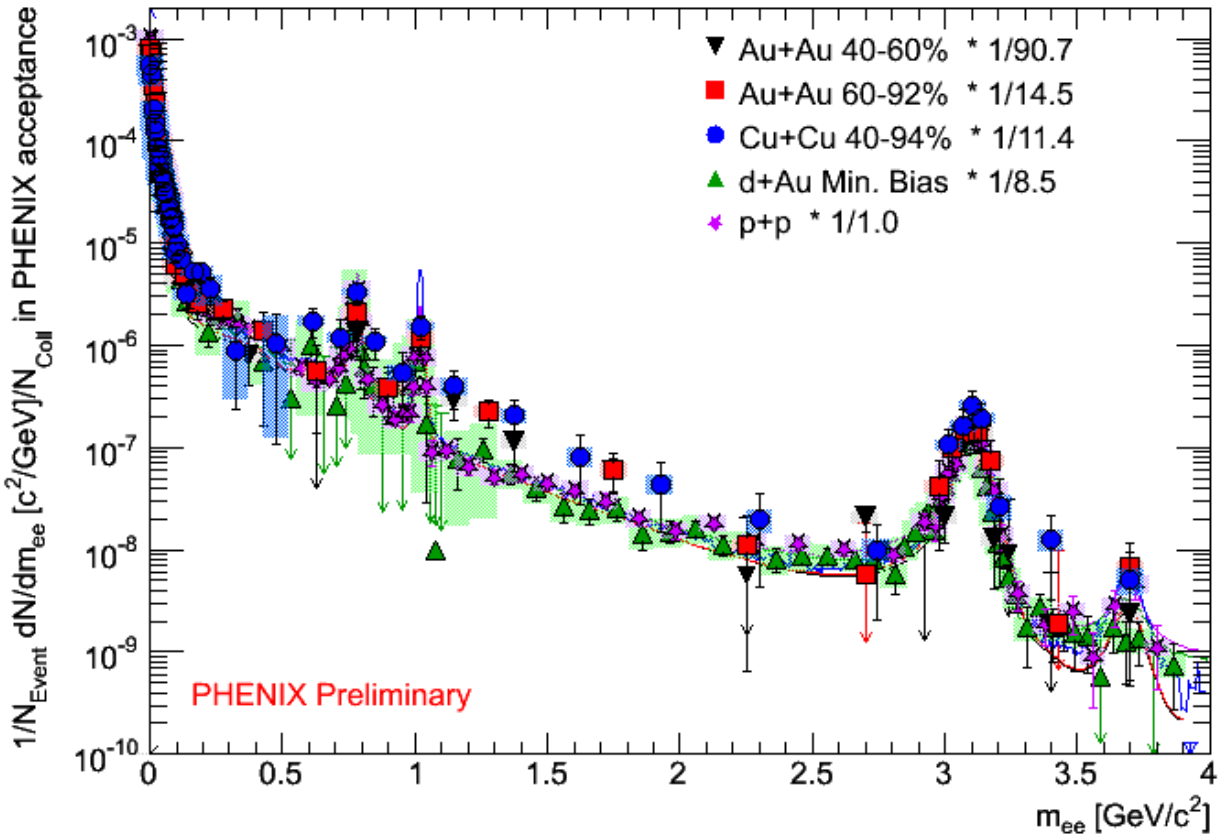


- Differentially in mass, shape is NOT what is expected from charm.
- spectrum is steeper

- true for most centralities (except maybe most central)
- IMR excess *not* seen in dAu!

Peripheral Heavy Ion vs d+Au

IMR enhancement?



The plot thickens…

- look at the most comparable Ncoll possible
  - peripheral AuAu, CuCu
  - dAu, pp
- the shape can be seen to be different from charm expectation.
- However, uncertainties are quite large in peripheral heavy ion data…
- pp and dAu fall right on top of cocktail.

IMR excess *not* due to cold nuclear effects

Summary

Dileptons access interesting, diverse physics!

New d+Au reference reinforces well established p+p reference

- baseline for Au+Au, Cu+Cu

Cold nuclear matter effects do not play major role in heavy ion interpretation

- Low mass enhancement in central Au+Au, Cu+Cu is a medium effect!
- Any open charm enhancement is not from initial state cold nuclear matter.

Dielectron outlook for PHENIX

- d+Au - p_T dependence, centrality
- extend p+p measurement to higher mass
- Hadron Blind Detector installed in 2010 increase precision of Au+Au measurement. (talk by M. Makek, EM Probes - Thurs)